Labor in Information Systems

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the labour of excogitation is too violent to last long.

Samuel Johnson. *Rasselas*. 1755.

Introduction

Labor is a condition of human existence in the Judeo-Christian tradition. Once out of Eden, we are condemned to work:

> cursed *is* the ground for thy sake; in sorrow shalt thou eat *of* it all the days of thy life; Thorns also and thistles shall it bring forth to thee; and thou shalt eat the herb of the field; In the sweat of thy face shalt thou eat bread, till thou return unto the ground; for out of it was thou taken: for dust thou *art* and dust shalt thou return.
>
> (*Genesis* 4. 17-19).

Labor is the punishment for false choice, and, having eaten of the tree of knowledge, we are compelled to choose further:

> The World was all before them, where to choose
> Their place of rest, and Providence their guide:
> They hand in hand, with wandering steps and slow,
> Through Eden took their solitary way.
>
> (Milton, 1674, Book 12, lines 645-648).

Following *Genesis*, labor has often been conceived as physical rather than mental labor and regarded as imposed but has less often been connected with choice.

Marx can be located in the Judeo-Christian tradition that regards labor as inescapable:

> The labour process … is purposeful activity aimed at the production of use-values. It is an appropriation of what exists in nature for the requirements of man. It is the universal condition for the metabolic interaction (*Stoffwechsel*) between man and nature, the everlasting nature imposed condition of human existence, and it is therefore independent of every form of that existence, or rather it is common to all forms of society in which human beings live.
>
> (Marx, 1976, p.290)

Labor for Marx is, then, the activity by which make their own history, by modifying the natural environment and their social, cultural, and environmental inheritance. Physical control over the environment, rather than the intellectual control over data or development of means of communication, is emphasized by Marx, in accord with the mid- to late-19th century context. Individual and communal *mental* labor are seen as significant to obtaining *physical* control over the environment, particularly in the treatment of science and technology (Marx, 1973; 1976; Warner, 2004; 2002). Science and technology can reduce direct human labor in the transformation of the environment into useful goods and offer progressive liberation from toil.

Economics, partly in its early development as a branch of political economy, developed the labor theory of value in the late 18th century and progressively departed from it from the 1870s. The set of *activities* understood as labor was similar to Marx's understanding, focusing on human physical work in the transformation of natural resources into manufactured products. The *role* given to labor was less extensive and not connected with humans making their own history. The labor theory of *value* was understood as the costs of the human labor involved in the manufacture of a product determining, or at least strongly influencing, the exchange value of that product. From the 1870s onwards the labor theory of value was increasingly displaced by market considerations. From an encompassing historical perspective, the labor theory of value can be seen to develop concurrently with manufacture and industrialization in Britain and then to be eroded as the overall rate of production was enabling increased leisure, the formation of a world market, and the diffusion of message transmission technologies (Warner, 2004). Labor and market determinants and theories of value might then be less antithetical than modern economics has tended to assume.

Economics has given limited attention to labor for informational purposes. Information processes have been recognized as increasingly economically significant (Stiglitz, 2000). Attempts have also been made to assimilate information goods to established economic models (Kahin and Varian, 2000). One crucial difficulty lies in the altered relation between selling and the exchange- and use-value of a product. Classically, in selling a product, including labor, the use-value of that good is alienated and its exchange value obtained. In selling a copy of an information product, the use-value of the product (apart from the aspect which is associated with exclusive ownership) is retained while its exchange value is still realized. The concept of information has been highly significant to the study of markets, with models incorporating concepts reminiscent of classical information theory (Shannon, 1993a).

Information science has given only limited consideration to concepts of labor and more strongly in its classic antecedents than its current practice. Charles Babbage, connected to modern information science through the gestalt of the computer (Rosenberg, V., 1974) and also obtaining a fugitive existence in economics (Schumpeter, 1961, p.541), discussed both mental labor and copying technologies (Babbage, 1963; 1989). Zipf founded his study of the dynamics of language on the principle of least effort. Zipf's law is concerned with the influence of this principle on the statistical distribution of word forms in spoken and written language (Zipf, 1936). Modern studies have addressed concepts of labor in the restricted sense of workforce requirements and also begun to give some attention to the human labor involved in the making of records for catalogues and databases (Hayes, 2000). The related, although seldom fully intersecting, field of communication studies has noted the absence of explicit considerations of labor combined with their simultaneous pervasive implicit presence and influence and has made some incomplete steps towards formalizing relevant concepts (Schiller, 1996).

Discussions of the information society (a significant, but not necessarily fully mutually communicating, context for information science (Brown, 1987; Webster, 2002)) have often counterposed capitalist and informational modes of development (Webster, 2002). Human labor and technology as embodied human labor have accordingly often been excluded from consideration. More recent discussions have developed the concept of informational labor (Dyer-Witheford, 1999), but without the further distinctions to be articulated here.

A coherent tradition of attention to labor in information systems in potentially relevant and contributing disciplines does not, then, exist to be reviewed. Nor is there even a scattered set of considerations to assemble. Rather, synthesis from implied concepts revealed in other considerations and patterns of activity must be attempted. The assumption articulated by Zipf (1936), of resistance to labor, can be simultaneously carried forward but changed. Rather then being received as a universal of human behavior, it is transformed into an empirically supported observation, of a widespread preference for economy of labor, theoretically connectable with the high costs of direct human labor.

The combination of a relative absence of explicit consideration with an implicit and pervasive presence suggests the possibility of constructing a powerful analytical framework, by transforming the implicit into the explicit. Labor, and the costs of labor, particularly the high costs of direct human labor, have greatly influenced patterns of activity central to information science, for instance, in the depth of humanly assigned description given to documents and records for databases and catalogs. A promise of robustness for the analysis can also be derived from the existence of analogous concerns with labor in ordinary discourse and in economics. The analysis should be relevant to fields other than information science, most obviously the cognate subject but separately developed discipline of information systems (Ellis, Allen, and Wilson, 1999).

The analysis must be approached progressively, with cumulative development of concepts. First, the idea of technology as a human construction will be introduced, from studies of productive technology, and extended to information technology, with information differentiated from productive technology. Then the different forms of labor embodied in information technologies and in systems enabled by information technology will be considered. Information technologies can be regarded as the embodied product of communal labor, the cooperation of humans working together, building on universal labor or the general intellect, historically accumulated human knowledge. A distinction between syntactic and semantic levels and processes, held in ordinary and some scholarly discourses, can be extended to syntactic and semantic labor, with information technologies regarded as capable of syntactic labor. The distinctions of universal from communal and of syntactic from semantic labor can then be made to yield insights into domains crucial to information science, into the information theory formalized by Shannon in 1948 (Shannon, 1993a) and information retrieval, with systems dealing with written language differentiated from those concerned with oral speech and images. Finally, the productivity of the concepts introduced will be reviewed.

Technology as a human construction

A view of technology as a radical human construction will be taken as the basis for subsequent discussion. Classically, this view was developed by Marx (Rosenberg, 1976; 1982; 1994), primarily, although not exclusively, with regard to industrial rather than information technologies:

> Nature builds no machines, no locomotives, railways, electric telegraphs, self-acting mules etc. These are products of human industry; natural material transformed into organs of the human will over nature, or of human participation in nature. They are *organs of the human brain, created by the human hand*; the power of knowledge, objectified. The development of fixed capital indicates to what degree general social knowledge has become a *direct force of production*, and to what degree, hence, the conditions of the process of social life itself have come under control of the general intellect and been transformed in accordance with it.
>
> (Marx, 1973, p.706)

Control mechanisms ('self-acting mules') and message transmission technologies ('electric telegraphs') are mentioned in this passage, but they are not its primary focus.

The idea of technology capable of performing autonomous labor, as exclusively industrial technology would have been broadly true of Marx's historical period:

> Only in large-scale industry has man succeeded in making the product of his past labour, labour which has already been objectified, perform gratuitous service on a large scale, like a force of nature.
>
> (Marx, 1976, p.510)

Information technologies for message transmission were increasingly diffused from the mid-1860s and these are acknowledged by Marx (Haye, 1980; Warner, 1999), in a later passage which takes an inclusive view of communication:

> the last fifty years have brought a revolution that is comparable only with the industrial revolution of the second half of the last century. On land the Macadamized road has been replaced by the railway, while at sea the slow and irregular sailing ship has been driven into the background by the rapid and regular steamer line; the whole earth has been girded by telegraph cables.
>
> (Marx, 1981, p.164)

The industrial technologies of the 19th century, such as the steam-hammer 'that can crush a man or pat an egg-shell' (Dickens, 1946, p.150), would have contained control mechanisms for variation in force (in one instantiation of the steam-hammer, a hand-controlled steam valve, which enabled the 'workman … [to] *think in blows* (Nasmyth, 1885, p.263)). Such mechanisms are not fully acknowledged in the classic concept of the simple machine (Minsky, 1967, p.7). Primitive logic machines, such as Jevons' logic piano, were also developed in the late 19th century (Gardner, 1958).

More recently, the Marxian conception of technology as a radical human construction has been extended to information technologies, understood, currently rather schematically, as a form of knowledge concerned with the transformation of signals from one form or medium into another (Warner, 2004). From this perspective, the language, including the written language, used by Marx can be seen as a cumulative creation of the 'general intellect'. Congruently with the growth of message transmission technologies, the late 19th century also witnessed the diffusion of non-verbal and abbreviated forms of writing, in logical notations, telegraphic codes, and shorthand.

The extension of a concept describing industrial technologies to include information technologies implies a continuity from industrial to information societies, with both potentially subsumed under capitalism. Familiarly, within discussions of the information society, continuities are counterposed to disjunctions with industrial and capitalist eras (Webster, 2002). A perspective derived from Marx can again be both novel and informative, in this context:

> It is not what is made but how, and by what instruments of labour, that distinguishes different economic epochs.
>
> …
>
> The writers of history have so far paid very little attention to the development of material production, which is the basis of all social life, and therefore of all real history. But prehistoric times at any rate have been classified on the basis on the investigations of natural science, rather than so-called historical research. Prehistory has been divided, according to the materials used to make tools and weapons, into the Stone Age, the Bronze Age and the Iron Age.
>
> (Marx, 1976, p.286)

Developments in the instruments of informational labor must be acknowledged, with the computer, as a universal information machine, displacing calculation and, increasingly, writing by hand, as well as special purpose information machines. Yet an underlying and underpinning continuity also exists, strikingly revealed in the theoretical development of the computer from an account of mathematical operations as the writing, erasure, and substitution of symbols (Warner, J., 1994). It is questionable whether modern information technologies constitute a transformation in material production rather than a significant addition (Warner, 1999a). An understanding of information as a perspective rather than as a disjunction from pre-existing forms of social organization is, then, preferred here (Warner, 1999b).

Awakening of dead labor

Classically, living labor is required to reawaken the dead labor embodied in machinery and thereby to confer use- and exchange-value on inert stuff (Marx, 1976, p.527; Warner, 2004). The fictional or mythic analogue to this process is supplied by Frankenstein giving life to his creation:

> With an anxiety that almost amounted to agony, I collected the instruments of life around me that I might infuse a spark of being into the lifeless thing that lay at my feet. It was already one in the morning; the rain pattered dismally against the panes, and my candle was nearly burnt out, when, by the glimmer of the half-extinguished light, I saw the dull yellow eye of the creature open; it breathed hard, and a convulsive motion agitated its limbs.
>
> (Shelley, 1998, pp.38-39)

The awakening of dead physical or industrial labor by human action has analogies in the use of information technologies, specifically, in one interpretation of non-determinism in automata theory, where determinism is understood as the automatic transformations in the intervals between human intervention (regarded as non-determinist). Human intervention would correspond to the awakening of dead labor.

Universal and communal labor

A distinction between universal and communal labor is made by Marx and can be adopted for the purposes here:

> We must distinguish here, incidentally, between universal labour and communal labour. They both play their part in the production process, and merge into one another, but they are each different as well. Universal labour is all scientific work, all discovery and invention. It is brought about partly by the cooperation of men now living, but partly also by building on earlier work. Communal labour, however, simply involves the direct cooperation of individuals.
>
> (Marx, 1981, p.199)

Universal labor, understood as science, discovery, and invention, could be regarded as an aspect of the general intellect which transforms the process of social life. Communal labor is crucial to the awakening and use of universal labor, both as embodied in technologies and written texts. In the narrative of Frankenstein, universal labor would be represented by the learning used by Frankenstein and by the instruments of life, and communal labor, here mediated through a single individual, in the application of that learning and those instruments.

With regard to 'building on earlier work', disciplines are understood to differ in the extent to which they are cumulative. Disciplines marked by the extensive use of syntactic operations, most obviously mathematics, are regarded as more strictly cumulative than the human sciences, and, even more the texts and artifacts studied in the human sciences (consider the reduction of Shannon's seminal work in 1938 on analogies between Boolean logic and switching circuits to material for secondary education, over the subsequent 50 years).

Semantic and syntactic labor

A distinction between semantics and syntax is made in ordinary discourse in literate Western societies. Semantics would be concerned with the issues of meaning. Syntax, by contrast, would be concerned with the form of messages and usually understood to include the grammar of spoken and, particularly, written language. The resonance of Searle's critique of claims for the intelligence of computers, that syntax is not semantics (Searle, 1980), may derive from its ordinary discourse roots and also points to more formalized distinctions.

In semiotics, in particular, a four level distinction has been constructed: from pragmatics or the intentions of the senders of messages and their effects on recipients; through semantics or issues of meaning; to syntactics or the form of statements (including formal logic); and to empirics or message transmission (including information theory in the Shannon sense). The distinctions have been brought to the study of information systems (Liebenau and Backhouse, 1991). In that context, the distinction of considerations of intention and meaning (pragmatics and semantics) from those of form and message transmission (syntactics and empirics) has proved sharper than the distinction between intention and meaning or between form and message transmission.

Issues connected with labor at each level of analysis have not received much attention but are still pervasive. They can be recovered and explicitly reconstructed from ordinary and from scholarly discourse, particularly from logic and discussions of mathematics.

The origins of the distinction between syntax and semantics in ordinary discourse can be traced to the transition from oral to oral and written verbal communication. In primarily oral communication, we receive not self-identical signs but variable and mutable signs (Vološinov, 1986). Primarily oral societies tend not to have concepts of grammar (and, self-evidently, not of orthographic correctness) and may differentiate good from bad speech by the effects it has on communal welfare. With the introduction of written language, a distinction between voice and speech develops (Aristotle, 1981, pp.59-61). Speech, embodied in written language, can be detached from its producers and made an object for grammatical and logical study (Harris, 1989). Transformations can then be carried out on the statement and it is these transformations that we understand as demanding labor. That labor is both physical and material, involving direct human physical effort and the material technologies for writing, and can be syntactic, concerned only with the form of statements, or semantic, engaging with considerations of meaning, in character.

An idea of syntactic labor is embodied in ordinary discourse and experience, although it is not necessarily made fully explicit. For instance, in 19th century legal practice in Britain and the United States, scriveners would mechanically copy documents and compare (technically, collate) them for accuracy by listening to an oral reading of the original or primary source. The lawyer in the practice would be responsible for the semantic labor or understanding and interpretation of documents (Melville, 1997). Babbage, in the mid-19th century, gives a detailed analysis of devices for copying (Babbage, 1963, pp.69-113; 1979; Hyman, 1982), although the devices, such as the stencil duplicator, which would displace hand copying, were not brought into wide use until the late 19th century (Day, 1996, p.683; Ohlman, 1996). For 19th century scriveners, syntactic labor is intimately bound up with physical labor (consider the effort of copying documents by hand) and is performed directly by humans, assisted by the established technologies of writing. Direct human labor has high costs, even under 19th century capitalism, where wages might be limited to the reproduction cost of that labor (Marx, 1976). In the diffusion of copying devices in the late 19th century, we can see the beginnings of a dynamic where machine labor, which has lower direct costs, is substituted for direct human syntactic labor.

Semantic labor, then, is concerned with transformations motivated by the context, meaning, or, in semiotic terms, the signified of the message. Syntactic labor, by contrast, is concerned with transformations determined by the form, expression, or signifier of the message. The aim of both forms of labor may be the production of further messages, for instance, a description of the original message or a dialogic response. Syntactic labor is better understood than semantic labor and the primitive operations possible (the writing, erasure, and substitution of symbols) can be recovered from accounts in formal logic, mathematics, and automata theory. These discourses, particularly automata theory and its concept of non-determinism, also contain the basis for a distinction of semantic from syntactic transformations.

The mid- to late 19th century was a crucial period for the emerging formalization of syntactic labor in formal logic. Boole (1854) demonstrated that the predominantly verbal form of the Aristotelian syllogism could be replaced by notational forms, with rule-governed transformations possible between expressions. Boole conceived his project as being concerned with the laws of thought and would not have explicitly differentiated syntactic from semantic transformations. A crucial restriction was that a symbol must retain an unaltered meaning (signifier inextricably linked to a single signified) during the course of a single argument. Semiotics itself, particularly in its North American manifestation in Charles Peirce, developed in its modern form in the late 19th century. Mechanical devices for carrying out syntactic transformations, from Jevons' logic piano to the more widely diffused Hollerith tabulating machine, also proliferate in this period. Modern message transmission technologies, such as the telephone and telegraph, develop from the early to the mid-19th century and particularly intensively in the 1870s (Warner, 2004). Message transmission technologies precede their theoretical modeling in Shannon’s 1948 information theory. Practical technologies and understandings often developed in advance of scientific theory, before the development of scientific research as a corporate enterprise in the late 19th century and the complexity of modern technology. Analogously, Boole’s logic and Peirce’s semiotics had a delayed impact on relevant academic discourses (Collins, 1998).

Following the convergence of mathematics and logic in the late 19th and early 20th century (Whitehead and Russell, 1962), discussions of mathematical logic clearly isolated the primitive operations of mathematics. These were the writing, erasure, and substitution of symbols (Ramsey, 1978) (there may be an implicit limitation to a discrete alphabet of symbols, analogous to the restriction of information theory, in its primary form, to discrete information sources (Shannon, 1993a)). From the perspective here, the writing, erasure, and substitution of symbols would be regarded as the primitive operations possible on discrete messages and labor as the work expended in these operations. Syntactic labor occurs when transformations are determined by the form or signifier and not directly motivated by the meaning or signified.

The models of the computational process developed in the 1930s by Church, Kleene, Post, and Turing may well have been influenced by the preceding isolation of the primitive operations of mathematics. Turing, whose model subsequently became dominant, began by comparing ‘a man in the process of computing a real number to a machine which is only capable of a finite number of conditions’ (Turing, 1937, p.231). The primitive operations of such a machine (the Turing machine) are the writing, erasure, and substitution of symbols, identical with those previously isolated in discussions of mathematics. The Turing machine is regarded as capable of imitating the operations of any information machine (with, again, a possible implicit limitation to discrete sources). The universal Turing machine, subsequently embodied in the computer, can imitate the actions of any given Turing machine. Recent evidence has revealed a greater continuity between Turing’s conceptualization of the computer and in 1936 and its subsequent invention, or demonstration of technical feasibility, in the early 1940s, particularly in dialogue between Turing and von Neumann (Davis, 2000, p.192). In the derivation of the conceptualization of the computer from an account of writing or graphic inscription, there is a curious, although suggestive, analogy with Marx’s remark, that, ‘It is not labour, but the instrument of labour, that serves as the starting point of the machine’ (Marx, 1976, p.500n).

A distinction between syntactic and semantic transformations, and the labor involved in those transformations, can be opened up from within mathematical logic, and, particularly, from automata theory. A critique of the reduction of mathematics to the writing, erasure, and substitution of symbols acknowledges that these are the primitive operations of mathematics but questions whether that is all a mathematician does and turns attention to the meaning of symbols and their connection with analogous terms and concepts (for instance, of number) in ordinary discourse (Ramsey, 1978). The distinction between syntax and semantics would also be analogous to the classic mathematical distinction between form and interpretation.

A crucial concept in automata theory is that of non-determinism. Non-determinism is understood in a number of senses but relevant here is the classic sense of a Turing machine or algorithm which reaches a configuration at which it halts and can only be moved on by choice from a human operator. Transformations in the deterministic periods between human intervention are conducted syntactically, with substitutions made on the basis of form of symbols (Turing, 1937, pp.131-132). Human intervention may then be made on the basis of the meaning of symbols or semantically, including selecting between different, but legitimate, possibilities for writing, erasure, or substitution, permitted by the syntax of the expression. Between the deterministic process and the non-deterministic intervention, a distinction between syntactic and semantic processes, and of labor, can be opened up.

Syntactic and semantic transformations are, then, formally similar, with a common set of primitive operations. For syntactic transformations, writing, erasure, and substitution of symbols are determined by the form of symbols alone (consider the current state and symbol scanned of a Turing machine determining the symbol written and next state). For semantic transformations, choice is motivated by the meaning of symbols. In some instance, semantic transformation may involve selection from syntactically legitimate possibilities. For instance, in the syntagmatic sequence, ‘The method by which mathematics arrives at its equations is the method of substitution’ (Wittgenstein, 1981, § 6.24), other selections from the paradigm could legitimately replace *substitution* but might less semantically informative or even semantically dissonant (everyday practice with spell checkers would confirm this). In historical practice, both syntactic and semantic transformations involved direct human labor, although labor of different types and costs (clerical as contrasted with intellectual work). Since the intensive development of modern information technologies from the late 19th century, syntactic transformations can be automatically executed, while semantic transformations continue to require direct human intervention. Syntactic transformations have lost of some of their material character and dispense with physical effort (contrast copying an electronic file with hand copying of a manuscript) and semantic labor has emerged more clearly as a separable category. Classically, but not necessarily successfully, computer science has been concerned with modeling semantic as syntactic processes, with far less explicit attention to the labor involved.

The automation of syntactic labor has substantial analogies with the replacement of physical by machine labor. For Marx, ‘with the help of machinery, human labour performs actions and creates things which without it would be absolutely impossible of accomplishment’ (Marx, 1976, p.389). Analogously, graphic inscription, and not just oral utterance, was crucial to the development of mathematics, and, for Russell, enabled the construction and consideration of regions of thought which would have otherwise been impossible to contemplate (Whitehead and Russell, 1962, p.2). Modern information technologies, particularly, although not exclusively, the computer, have enhanced the possibilities of exactness classically associated with writing (Warner, 2001). The industrial 'machine [was] …a mechanism that, after being set in motion, performs with its tools the same operations as the worker formerly did with similar tools.' (Marx, 1976, p.495). With information technologies, there has been a greater change in the tools of labor, reflecting and embodying the partial dematerialization of syntactic processes, but a comparable continuity in the primitive operations possible. With mechanization of physical labor, the 'number of tools that a machine can bring into play simultaneously is from the outset independent of the organic limitations that confine the tools of the handicraftsman' (Marx, 1976, p.495). Similarly, a modern database or catalog enables a control of complexity over a larger amount of data than would be remotely possible for a single human mind, not enabled by modern technologies. Large-scale industry had to produce machines by means of machines (Marx, 1976, p.506) and the construction of modern information technologies, for instance the design of logic-gates, is similarly dependent on existing information technologies. The threat to direct human syntactic labor offered by modern information technologies has not necessarily been fully recognized within relevant disciplines, such as mathematics.

Semantic and syntactic processes are formally similarly, both involving the writing, erasure, and substitution of symbols, and it is these similarities which have enabled the modeling of semantic processes as syntactic transformations. Semantic and syntactic processes differ, not in their form, but in their motivation, with syntactic transformations determined by the form of symbols and semantic processes motivated by their meaning or signified. Accordingly, they also differ in the labor involved. An analogy is discernible with the critique of the view of mathematics as consisting solely, of the erasure, writing, and substitution of symbols and the questioning of whether that is all a mathematician does (Ramsey, 1990): a mathematician's thought, for instance, selecting between synchronically legitimate alternatives, would correspond to semantic labor. To pursue the analogy with Marx's comment on the instrument of labor as the starting point for the machine, regarding syntactic and semantic transformations as identical would be to confuse the instrument of labor and its autonomous operations when embodied in a machine with the whole labor process, which includes elements of direct human intervention. The modeling of semantic processes as syntactic transformations rests of the formal similarities between the processes but has also exposed the differences in motivation and the difficulty of modeling semantic as syntactic processes (Searle, 1980; Warner, 2002).

Both syntactic and semantic labor are costly when performed directly by humans. The costs of that labor can be related to its production costs in education into literacy and in the acquisition of knowledge for particular semantic domains, and also to the markets for educated human labor. In relation to the specific concerns of information science, the direct human labor required to describe documents for catalogues is known to be costly (to describe a document to standard required for World-Cat is estimated to cost in the region of 40 US $). Labor delegated to information technologies, by contrast, is relatively, and increasingly, less costly than direct human labor. For instance, the costs of automatically creating an index to a record would be minimal, once the information technologies for this (in both their hardware and software aspects) are formalized and robust (these technologies can be regarded as the products of communal labor working on accumulated universal labor or the general intellect).

The contrasting costs of direct human and delegated syntactic labor create the possibility of a dynamic similar to that between physical or material and industrial labor. Dead labor, embodied in machinery, is substituted for direct human labor, first industrial for physical labor, and then, in modern practice, intellectual for human intellectual labor, both reducing the direct costs of the processes and enabling process of a scale previously impossible. Syntactic processes, such as copying, creation of indexes where the metalanguage of description is directly derived from the object language described, and message transmission, which, in historical practice, were directly performed by humans, can be increasingly delegated to information technologies. One approach, emerging in practice before being formalized in theory, in a number of areas, such as information retrieval and citation analysis for research assessment (Warner, 2000a; 2003b), is to combine syntactic and semantic transformations, using information technologies to manipulate data but reserving human judgment for the interpretation of results.

Summary

Distinctions, then, have been created between syntactic and semantic labor, formalizing the distinctions from its ordinary discourse analogue and adding the idea of labor to that of transformations and levels of analysis. A powerful dynamic, continuous with the dynamic of the substitution of dead for living labor under capitalism, has been detected, but in relation to intellectual and not physical labor. The dynamic may have predictive value as well as current and retrospective application, anticipating patterns in future developments.

Information theory

Information theory was influential in the early development of information science (Shannon, 1993a; Weaver, 1949; Wiener, 1954; Bar-Hillel, 1964; Rosenberg, V., 1974; Roberts, 1976; Brown, 1987), providing models for communication which were also adapted to the understanding of information retrieval. Its early promise as a metaphysic for the field of information science was not fulfilled, but there are current indications of a more informed revival and a subtler recognition of its continuing relevance to communication (Warner, 2003a).

Concepts of labor are both implicit, and to some extent, explicit, in information theory. Historically accumulated intellectual labor is embodied in the coding systems (telegraph codes, systems of shorthand, Morse code, and alphabetic written language itself) which preceded Shannon's formalization of information theory. These coding systems can be described in terms of information theory, and, both historically and biographically (Horgan, 1990; Warner, 2003a), may have impelled its formalization. Information theory is primarily adapted to discrete rather than continuous information sources, for instance to written language rather than oral speech. In this sense, it deals with the congealed products of communication rather than with forms of communication where process and product are inseparable. There is a continuity with Zipf (1936), in the statistical perspective on communication, and specifically, in the understanding of a word, as 'a cohesive group of letters with strong internal statistical influences' (Shannon, 1993c, pp.197-198). Ideas of labor emerge with regard to selection of messages from the information source, in work done in encoding and decoding, and in the search for economy in the use of the transmission channel. Dialectical relations between these specific forms of labor are also discernible.

Labor in selection (*selection labor*) is implied in the choice of messages from the source to accord with combinative constraints of the message sequences. Selection labor can include both physical and intellectual components. For instance, the messages for selection could be the individual letters of the Roman alphabet and the combinative constraints those of the English language lexicon. It the number and variety of the messages for selection are increased to accord with the anticipated combinative constraints (for instance, with printers' ligatures), recurrent labor in selection is reduced but additional intellectual labor is expended in learning how to choose between the increased set of messages (the additional labor expended in learning could be regarded as non-recurrent capital cost (Warner, 2003a)). Coding practices existing before the formalization of information theory can, then, both embody descriptive understandings of the principles of information theory and a preference for economy in the total labor to be expended (Cherry, 1978).

Encoding labor by the transmitter is more explicitly acknowledged, rather than only implied, within information theory, although as delays or time consumed rather than directly as labor expended (Shannon, 1993a; Verdú and McLaughlin, 2000). Labor in encoding is understood as the work done on the message to produce the signal and would often be performed with the aim of reducing demands on channel capacity (corresponding to a preference for economy in the use of the channel as a product of labor). A common strategy, formalized within information theory, would be to reduce the redundancy of the message when transforming the message into the signal. The reduced redundancy in the signal can render it more vulnerable to corruption by noise in a manner which complicates reconstruction of the message from the signal by the receiver. This strategy would be exemplified by systems of shorthand and by Morse code: systems of shorthand enable operations on messages, for instance sequences from the English lexicon, to transform them into reduced signal sequences, by replacing redundant characters by a single symbol; Morse code uses short signal sequences for frequently occurring characters in the message. Other, post-Shannon, coding systems, such as those for the compression of text files, use more deliberately theoretically informed techniques to reduce redundancy in the signal (Verdú and McLaughlin, 2000). The receiver transforms the received signal into the message and the amount of labor expended in this operation tends to be directly, rather than inversely, correlated with encoding labor (the production of the message sequences produced by decoding operations may require further physical or material labor). The receiver then passes the message to the destination and any distortions produced by uneliminated noise can complicate interpretation by the destination. Historically, for instance, in mid- and late 19th century practice, encoding and decoding has been conducted by direct human labor (for instance, by a human telegrapher), but, in modern practice, is likely to be delegated to information technologies.

Redundancy has various effects on the amounts of labor required at different points in the process of communication modeled in information theory. Redundancy in message sequences increases physical and material labor in selection and composition but may reduce intellectual labor in selection (contrast the physical or material with the intellectual labor required to complete the message sequence, *afterw*, in the English language lexicon, once combinative constraints have been mastered). Redundancy of the signal transmitted counteracts noise in the channel but uses channel capacity (channel capacity is either the product of labor, or, in historical instances, involves direct human labor). Redundancy in the signal received may reduce labor in decoding at the receiver and in interpretation by the destination.

Concepts of labor, understood primarily as direct human labor, are more explicit and developed in the related field of cryptography than information theory, possibly due to the immediate experience of constructing and deciphering systems. For a cryptanalyst, a secrecy system is strongly analogous to a noisy communication system and the cryptogram to the distorted signal (Shannon, 1993b, p.113). Redundancy of the signal could assist the transformation of the signal into the message by the receiver, and, similarly, redundancy in the original messages enciphered makes a solution possible (Shannon, 1993b, p.117). Labor expended in encoding is broadly correlated with labor expended in decoding by intended receivers and in deciphering by interceptors. The balance between labor in encoding and decoding would also be implicitly understood in ordinary discourse references to the complexity of coding systems. Specifically, within cryptography, a unicity point is distinguished, after which there will usually be a unique solution. Data beyond the unicity point can reduce labor in deciphering but further additional data may not reduce labor any more. At a trans- rather than individual system level, a dialectic over time can be detected between the introduction of new systems, resistant to known methods of solution, and the development of cryptanalytic techniques for deciphering such systems (Shannon, 1993b, p.132). From the distinctions established here, this process can be seen as the transformation of communal into universal labor. For individual systems, it is recognized that perfect secrecy is possible, for instance, where the number of possible messages is small, but that the key must then be equivalent in amount (and, by implication, in labor expended on agreeing and transmitting the key) to the massages for selection (Shannon, 1993b, p.111) (Warner (2003a) gives a historical example of equivalence between labor expended in the key and the message, with only two messages for selection).

Complex, but still comprehensible, patterns for the distribution of labor can, then, be discovered in information theory. A principal aim of information theory was to enable economy in the use of a channel for transmitting signals, corresponding to a preference for economy in use of the products of labor. Achieving economy in transmission tends to involve delays or labor expended in encoding by the transmitter and decoding by the receiver. If redundancy in the signal is greatly reduced with the aim of economy in transmission, reconstruction of the message by the receiver and interpretation by the destination may be complicated by the effects of noise. The distribution of labor between the components in the communication process, between selection, encoding, transmission, decoding, and interpretation, can be expected to reflect the costs of direct human labor and of the technologies in which accumulated labor is embodied. Information theory itself was developed by individuals working in communal contexts, building on the theoretical (preceding analogues to information theory (Cherry, 1978)) and practical (working coding systems) products of historically accumulated labor. With publication, and the transition from the relatively closed context of wartime cryptography, information theory itself becomes part of universal labor, although with delayed diffusion to public consciousness and the design of coding systems.

Information retrieval systems

I wish, in this context, to confine attention to system predominantly concerned with written language. Oral and non-verbal forms of graphic communication, which have undergone less clearly marked historically accumulated forms of coding, present different issues for retrieval system design. Most obviously, they do not necessarily offer readily distinguishable syntactic units with potential semantic significance.

Two antithetical, if not always clearly distinguished, traditions can be detected in information retrieval system design and evaluation. The idea of query transformation, understood as the automatic transformation of a query into a set of relevant records, has been dominant in information retrieval theory (Ellis 1996). A contrasting principle of selection power has been valued in ordinary discourse, librarianship, and, to some extent, in practical system design and use (Ellis, 1984; Wilson, 1996). Philosophical antecedents to the idea of selection power can also be found (Warner, 2000a) (the derivation of the term, *intelligence*, from *inter-legere*, or to choose between, would be relevant). The debate between query transformation and selection power may not be resolvable within either paradigm, but, in this context, I wish to take the privilege of assuming selection power as the founding principle for system design, evaluation, and use.

Selection power may be the design principle, but *selection labor* could be regarded as the primary concept, from which selection power is derived. Let us assume that a certain quantity of selection labor, associated with the number and variety of objects for selection, is distributed between system producer and searcher, with the possibility for variation of the distribution between the producer and searcher.

Selection power is valued by a searcher as it reduces their selection labor (and an exhaustive serial search may not be a practical possibility). *Description labor* by the system producer tends to aim to increase the selection power of the searcher and reduce their selection labor (description labor is understood to include cataloguing, or document description, and classification, or subject categorization, incidentally revealing the congruence between their aims). The semantic and syntactic intellectual labor embodied in objects or documents described is here treated as a given. The description labor of the system producer can contain elements of syntactic labor, for instance, transcription or algorithmic transformation of the object-language of documents described into the metalanguage of index representations, and of semantic labor, for instance the application of thesaural terms derived from a controlled vocabulary or of cataloguing codes to the description of documents. In the 19th century, both syntactic and semantic labor might have involved continuous human intervention (consider the creation of *Palmer's Index to The Times* and the primarily syntactic labor of transcribing newspaper headlines as index entries); in modern Western practice, syntactic labor is delegated to humanly constructed technologies, and, accordingly, human intellectual labor becomes almost exclusively semantic.

Universal labor is understood as information technologies, in both their hardware and software aspects, and communal labor as the awakening or use of those technologies, including semantic record description.

A diagram may clarify the application of the distinctions between semantic and syntactic and communal and universal labor to information retrieval systems (see Figure 1). The classification of systems from highly to loosely structured is tautological in that it is derived from the objects described and the framework of description, but may still be informative.

The *Financial Times*, in its various searchable manifestations, provides a peculiarly pure example of the distinction between syntactic and semantic labor. It is available as a web-resource without payment at the point of use, with largely syntactically generated search facilities which operate on identifiable units of the source. It is also available with additional description, generated from human semantic labor (which could be syntactically assisted), from a number of vendors. For instance, the Dialog available file labels articles by geopolitical region and product/industry names, including NAICS (North American Industry Classification System) code. Direct payment at point of use is made for the resources which embody additional semantic labor. The continuity of such sources is market testimony to readiness to pay for additional selection power (and further evidence for the congruence of the concept of selection power with ordinary discourse understandings and everyday practice). Provision of both types of resource involves similar access to the universal labor embodied in information technologies and comparable communal labor to reinvigorate those technologies.

Syntactic labor	Semantic labor			Universal intellectual labor	Communal intellectual labor		Selection work of searcher
Syntactic labor (machine and delegated to technology).	Human semantic labor (different degrees of intensity).	**Highly structured**	OCLC World Cat; Financial Times with added indexing.	Information technologies	System construction and maintenance (search engine or directory structure).	Record creation (standards for cataloguing and subject description): human semantic work.	Reduced.
		Medium structured	BUBL (Internet Directory): Lycos UK	Algorithms for automatic (syntactic) processing and indexing of written language.		Description of resources; creation and maintenance of directory structure: human semantic work.	Intermediate.
	Human semantic labor not applied.	**Loosely structured**	Google (Internet search engine); Newspaper web site; Palmer's Index to the Times.			Automatically generated descriptions.	Intensive.

Figure 1. Forms of labor in information system construction and searching.

The costs of human labor in description can be more specifically considered. For instance the costs of creating a catalogue record to the standards required for *World Cat* are in the order of US $40. The labor in description may contain syntactic elements, for instance, in transcription, but will be predominantly semantic. Costs of syntactic labor, by contrast, in storage, manipulation, and transmission of records have diminished historically, and continue to diminish, as communal human labor is transformed into universal labor. Labor invested in record description increases the selection power and reduces the selection labor of the searcher.

Returning to the overall schema embodied in the diagram, we can see that producers of information systems, from highly to loosely structured, have comparable access to universal intellectual labor and to its products, embodied in the language they use, and, specifically, in the information technologies available. Comparable, although contrasting, levels of communal labor would be required for system design and maintenance. Strikingly different levels of direct human labor are given to document description: for records in library and union catalogues, intense semantic labor is required (whose intensity could be related to the exactness required); for Internet directories, selection and description of resources, although to less exacting standards; for Internet search engines, very little, if any, additional semantic labor. The communal labor invested in the description of resources reduces the selection labor of the searcher (with both forms of labor reflecting the high costs of direct human employment).

The model can be validated, from macro- to micro-levels. At a macro-level, syntactically based systems proliferate (consider the variety of Internet search engines), while semantically enriched systems, such as *World Cat*, may occupy unique market positions. Simultaneously, the search facilities of syntactically based and semantically enriched systems, products of universal labor, are converging in appearance and power. At an intermediate level, the function of library cooperatives has changed over time, moving along the horizontal axis of the diagram, from adapting universal labor to a concern with sharing the descriptive labor of cataloguing (from awakening Frankenstein's monster to distributing its limbs). At a more micro-level, the relative costs of communal and universal labor, considered in relation to market demand, form the decision framework for the conversion of historical resources from paper to electronic form (including *Palmer's Index to The Times*). For information retrieval systems, the communal labor invested in description at production reduces the labor required at use. The distribution of direct human labor between producer and searcher may depend on the nature of the market for the product.

Information retrieval systems, then, can be seen to exhibit the fundamental dynamic of capitalism, the substitution of dead for living labor, although semiotic rather than physical labor. The specific, and already known, dynamic of bibliography between order and chaos is accentuated. Chaos is further enabled by the reduced costs of making information public. Possibilities for order are enhanced by the availability of delegated syntactic labor (although the limitations of such labor are becoming painfully known). The resources giving control themselves contribute to overall disorder (consider Search Engine Watch, at http://www.searchenginewatch.com/ in relation to Theodore

Besterman's *A World Bibliography of Bibliographies* and classic concerns with bibliographic proliferation).

Conclusion

Attention to labor in information systems has, then, made some powerful forces and implicit concepts more explicit. An established distinction between universal and communal labor has been adapted to information technology and systems. The concept of labor has been added to more familiar distinctions between syntactic and semantic levels of analysis and processes. These distinctions have been used to clarify issues and patterns of activity in information theory and information retrieval. Application to other domains within information science would be possible. A dynamic involving the substitution of dead for living human labor, continuous with the dynamic of capitalism, has been detected. The dynamic may have predictive value as well as explanatory power and could be used to inform information policy decisions. The social and technological aspects of information science, often divided from each other, have been brought together and the divide between the social and the technical partly dissolved. Technology has been humanized, explicitly recognized as a human construction, and the human user of technology also humanized, with full recognition given to human judgment and choice.

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